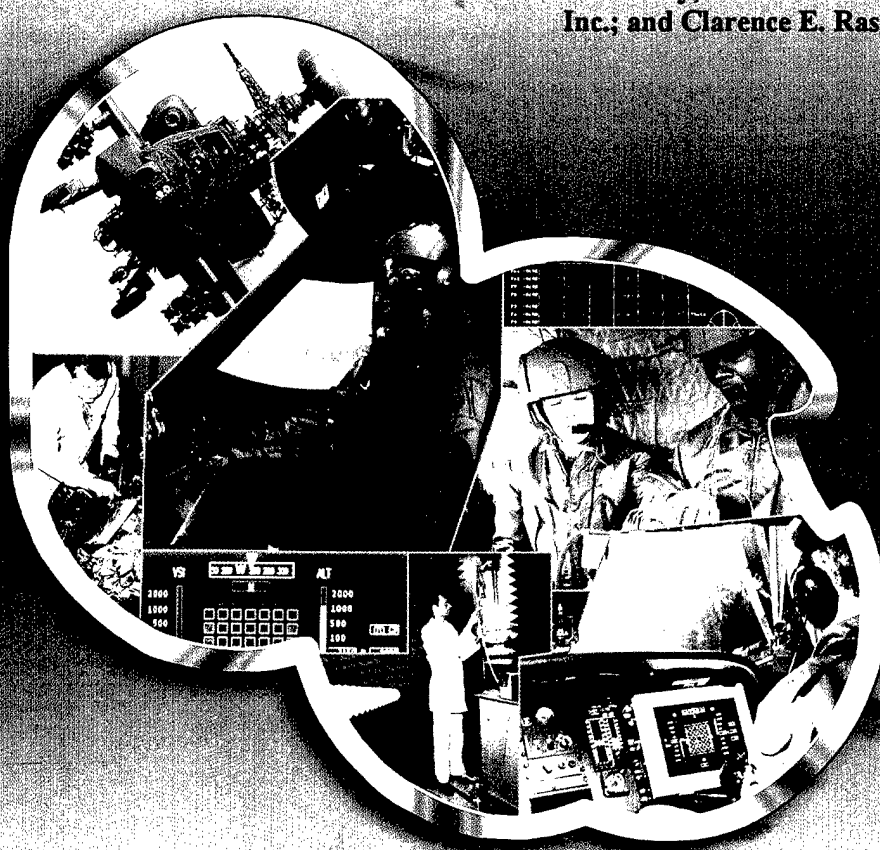USAARL Report No. 2002-13

# Evaluation of Pinch Correction in the Phase 2 Microvision, Inc. Aircrew Integrated Helmet System HGU-56/P Scanning Laser Display

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An evaluation of a pinch correction technique for use in the Microvision, Inc., Aircrew Integrated Helmet System version of a retinal scanning laser helmet-mounted display was conducted. Using specially selected grill test patterns, the ability of the display with pinch correction to maintain scan line alignment at the ends of the scans was determined to be greatly improved. This improvement was visually demonstrated using additional text character test patterns.

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## Introduction

The project manager, Aircrew Integrated Systems (PM-ACIS), Huntsville, Alabama, has established a program with Microvision, Inc., Seattle, Washington, to develop a technology demonstrator to determine the capability of a retinal scanning display (RSD) to meet RAH-66 Comanche helmet mounted display (HMD) performance specifications. Under this program, titled Aircrew Integrated Helmet System (AIHS) HGU-56P VRD system, Microvision developed and delivered to the Army a laser-based HMD for evaluation by the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, Alabama. USAARL Reports No. 99-18, 2001-06 and 2002-01 provided evaluations of earlier versions of the Microvision HMD. This report constitutes the findings of an evaluation of the phase 2 HMD which includes pinch correction (Figure 1). This correction should improve the spatial performance near the horizontal edges of each display. Pinch correction improves the spacing inequalities between pairs of lines in scanned displays. This is an important requirement for overlapped biocular HMDs.

A description of the Microvision HMD system can be found in a recent report (Harding et al., 2001a) and will only be described briefly here. For each side of the binocular display, light from a laser beam is divided into two beams for simultaneous scanning in both forward and aft (retrace) directions. This scanning technique reduces the bandwidth requirement for the horizontal and vertical scanners housed in the HMD. Beam intensity is adjusted by electro-optical modulators. These modulators in effect control the intensity and duration of each pixel as it is drawn by the sweeping beams. Timing circuits control the duration of pixels, which changes as a function of lateral position.

In the USAARL's last evaluation (USAARL Report No. 2002-01), Microvision engineers had incorporated new electronics that controlled the positioning of pixels more precisely. The present version takes care of line spacing issues in the periphery. Pinch correction should not improve the MTF but may have a subtle affect on the CTF, which is more closely impacted by line spacing.

The results presented here are limited and were taken during a one-week period of testing at USAARL. Microvision provided onsite engineering support for the testing.

## The nature of pinch correction

In a scanning display (e.g., cathode ray tubes), lines are generally scanned horizontally, and contrast is achieved by increasing or decreasing electron beam intensity as it passes over the display area. The RSD is the same with the exception that the scanning area is the retina instead of a phosphor, as in the case of the CRT, and the beam is a laser instead of an electron beam. For each eye, two laser beams are scanned back and forth across the retina. As the beams approach an edge they begin to diverge and converge in a geometrically defined way. Figure 2 shows graphs of scanned lines with and without pinch correction. Figure 2A shows the case where two lines are being scanned simultaneously without pinch correction. As seen in the figure near the right edge,

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distance A is shorter than distance B, but line separations are the same in the middle of the display. Also notice that scanned lines cross near the edge where the top line crosses the previously scanned bottom line of the line pair. This crossing reduces the usable active area of the display and thereby reduces system efficiency.

Compare this with the pinch correction shown in Figure 2B. Here a second harmonic solution has been applied to the scanned lines. Note that near the right edge, distance A and B are now the same. In addition, the line crossing takes place much closer to the edge thereby increasing the usable are of the display thus increasing system efficiency.
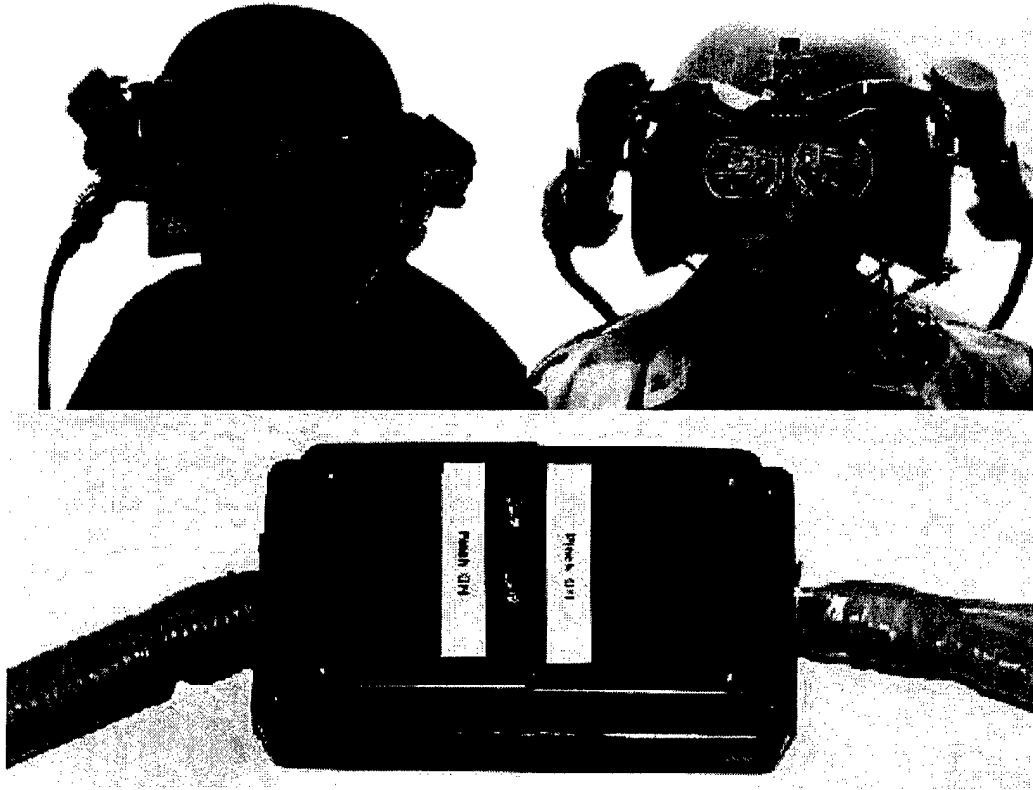


Figure 1. Photographs of Microvision AIHS HMD and the electronic switches that control pinch correction in each side of the HMD.

## Testing pinch correction

To test pinch correction, we devised a horizontal grid pattern composed of two lines on followed by five lines off and the pattern repeated over a given area (Figure 3B). Due to the odd number of lines in the pattern, the grill pattern tests different line pairs sequentially. Figure 3A shows another graph of the scanning lines with pinch correction. We have numbered the lines 0, 1, 2 and 3. Lines 0 and 1 traverse the screen from left to right and lines 2 and 3 traverse the screen from right to left. The grill pattern displays line pairs 0-1, 3-0, 2-3, and 1-2 sequentially. Line pairs 0-1 and 2-3 scan in the same direction, whereas line pairs 3-0 and 1-2 scan in opposite directions. By photographing the displayed grill pattern, the thickness of the line pairs could be measured thereby evaluating the effectiveness of the pinch correction.

If pinch correction is effective, all line pairs should have the same photographic thickness. Figure 4 shows images captured from the left edge of the left channel. The photograph in Figure 4A was taken with pinch correction off. Note that every fourth pair of lines was thicker than the others. As this pattern did not agree with our prediction of the non-pinch corrected pattern, calibration patterns were examined for inconsistencies. Unfortunately, none were found. After further investigation, we discovered a small piece of black tape stuck to the scanner housing. The tape had torqued the scanner housing. Removing the tape and recalibrating solved the problem. Figure 4B shows the proper non-pinch corrected pattern consisting of alternating thick and thin line pairs. Figure 4C shows a good example of properly aligned optics coupled with pinch correction. Note the uniform thickness of the horizontal line pairs.
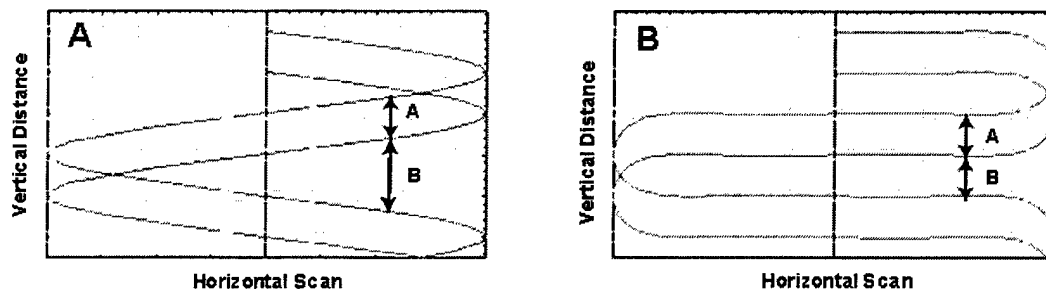
Figure 2. Graphs of scanned lines representing dual scans with no pinch correction (A) and dual scans with pinch correction (B). Note the difference between distance A and B in (A), whereas with pinch correction (B), the distances are the same. Original graphs supplied by Microvision, Inc.
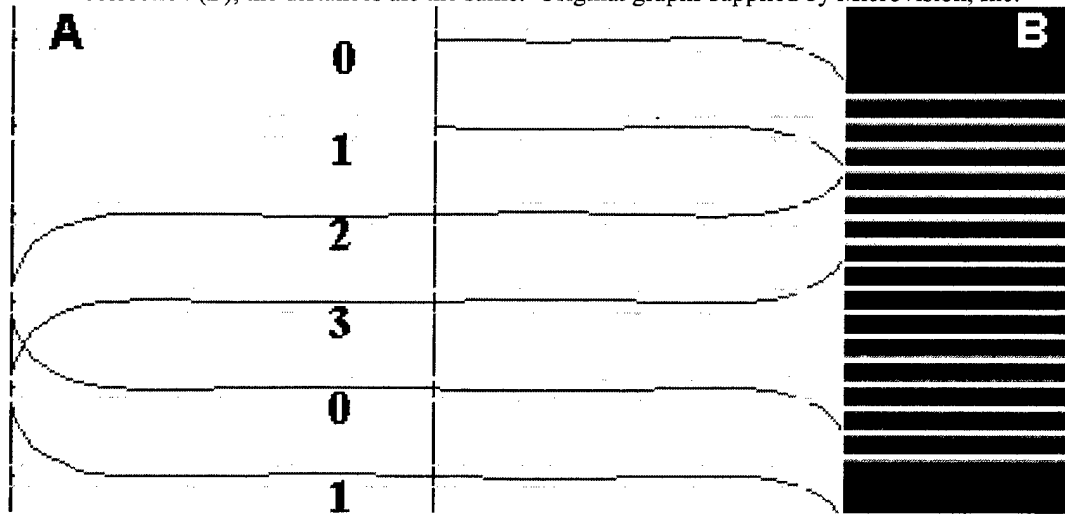
Figure 3. Line numbering and pattern for evaluating line pairs. (A) Graph of dual scanning with pinch correction. The lines are numbered 0, 1, 2, 3, depicting the four line conditions. (B) Horizontal grill pattern comprised of 2 lines followed by five lines off and the pattern repeated. Original graph (A) supplied by Microvision, Inc.
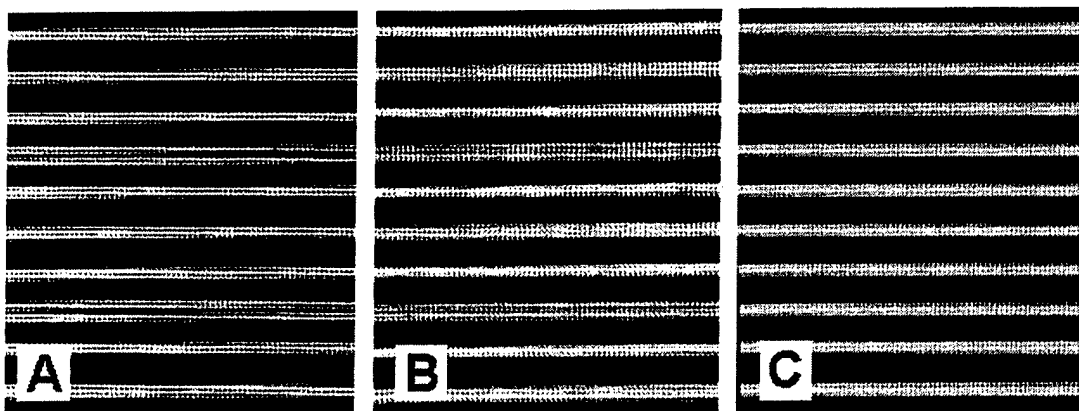
Figure 4. Photographic images of line pairs near the left edge of the left side display. (A) Non-pinch corrected condition coupled with a torqued scanner housing (see text for explanation). (B) Typical non-pinch corrected pattern consisting of alternation thick and thin line pairs. (C) Pinch-corrected condition with proper calibration and alignment.

## Text images in periphery

To view the effects of pinch correction in another way, 5 by 5 text characters were displayed near the lateral periphery. Figure 5 shows photographic images captured under the two conditions. Letter fragmentation or gaps are seen in the uncorrected condition, whereas the pinch-corrected condition shows fairly good character definition
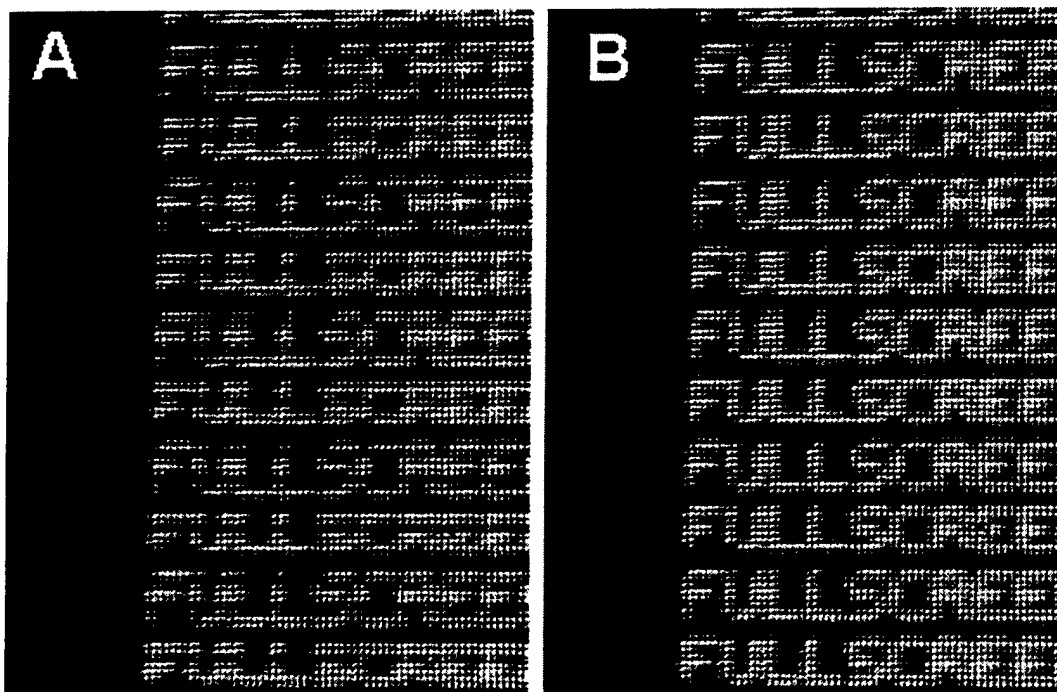


Figure 5. Photographic images of 5 by 5 text characters. (A) Non-pinch corrected text imagery. (B) Pinch corrected text imagery.

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## Modulation transfer function (MTF)

The MTF was calculated for the middle of the display to document once again the spatial resolution of the Microvision HMD. The MTF has become a benchmark used to assess improvements in the resolution of the system. Here we measure the MTF to benchmark the system, at this point in the development cycle, and for no other reason as the only change to the system from the one evaluated last (USAARL report 2002-01) is the introduction of pinch correction. Since pinch correction does not affect line width, it should have no affect on the MTF. Single vertical and horizontal lines were displayed in the middle of the field-of-view. The lines were photographed and processed, and the resulting data imported into Microsoft Excel for frequency analysis (Harding et al, 2001b). Figure 6 shows the vertical and horizontal MTFs calculated from the photographic images.

The vertical MTF has a modulation of about 0.23 modulation at the Nyquist frequency, (approximately 15.6 cycles/degree) and the horizontal MTF has a modulation of about 0.17 at the same frequency. These MTFs show slight improvement over the MTFs measured last (Harding et al., 2001b).
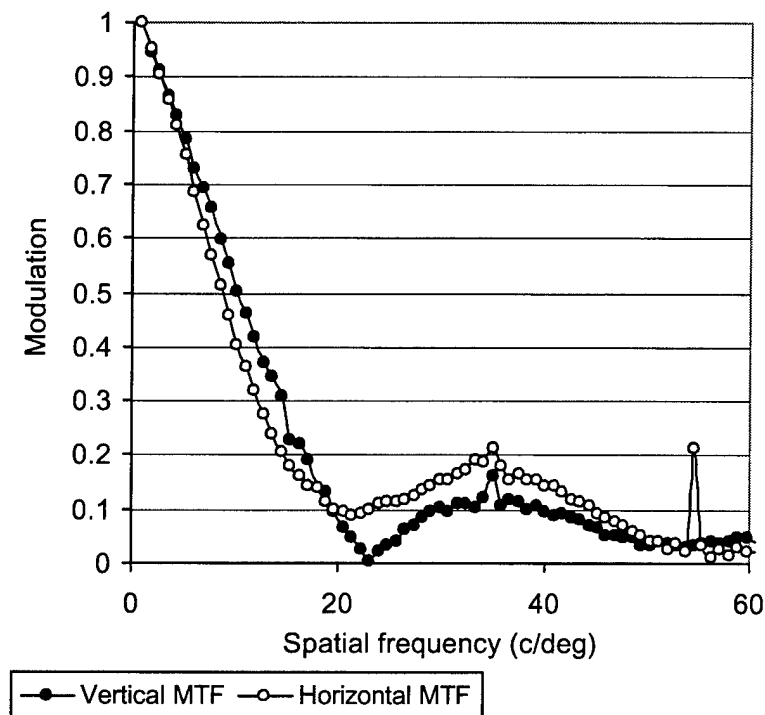


Figure 6. MTFs measured from the left side of the HMD.

## Summary

The pinch correction evaluated here appears to be a major milestone in the development of the RSD. The correction works as evaluated with grill patterns and with text imagery. The line spacing issue seems to have been solved. Of note however, is the inability of present calibration techniques to identify the line spacing problem encountered when the scanner housing was affected by the tape (Figure 4A). Calibration techniques must be developed that not only address sub-pixel alignment but also address the issues of line spacing in the periphery.

# References

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